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Numerical modelling of Triple Junction Tectonics at Karlıova, Eastern Turkey: implications for the mechanism of magma transport

Özgür Karaoğlu (1,2), John Browning (2,3), Mohsen Bazargan (2,3), and Agust Gudmundsson (2)

(1) Department of Geological Engineering, Eskisehir Osmangazi University, Eskisehir, Turkey (ozgur.karaoglu@deu.edu.tr), (2) Department of Earth Sciences, Royal Holloway University of London, Egham, United Kingdom (ozgur.karaoglu@rhul.ac.uk), (3) Department of Earth Sciences, University College London, London, United Kingdom

Few places on Earth are as tectonically active as the Karlıova region of eastern Turkey. In this region, complex interactions between the Arabian, Eurasian and Anatolian plates occur at the Karlıova Triple Junction (KTJ). Suitably stressed crustal materials of the extruded block on the Karlıova-type triple junctions are potential regions for magma ascent. The relationship between tectonics and magma propagation in triple junction tectonic settings is, however, poorly understood.

This study discusses the mechanism of magma propagation in the Karlıova Triple Junction (KTJ) tectonic regime. We aim to demonstrate how the geometry and mechanical properties of faults and rock units affect magma propagation under a variety of tectonic boundary loads. We discuss the geologic setting of the KTJ and the manifestations of shallow and deeper magma chambers within the crustal segment. Our numerical modelling study aims to quantify the crustal response of various tectonic regimes in Eastern Turkey. The region is characterised by lithological heterogeneity which is considered in our models. We present a series of two-dimensional and three-dimensional numerical models to help constrain evolving ideas regarding inversion and transtensional tectonics in an east-west direction along the KTJ. We also consider a north to south striking profile which is subjected to regional compression and local extensional tectonic phases which likely operated in the region $\sim$3 My. A three-dimensional model is presented to investigate the effect of regional differential stresses.

Our numerical models demonstrate that the regional tectonic stresses that are capable of encouraging magma-chamber failure and dyke propagation. Turnadağ volcanism at the western part of this triple junction has been fed by a shallow magma chamber located at 8-10 km depth during E-W extension. The Varto caldera is also fed by a shallow magma chamber at 8-10 km depth. Numerical results show that if the region were to be subjected to an E-W-oriented compressional regime, then magma propagation would be unlikely. Magma transfer between the magma chambers of the Varto volcano and the Özenç volcanic province exhibit complex stress interactions. The pattern of local stress changes from the eastern part of the triple junction to the western part. Even though this province has experienced N-S-directed compression, inversion tectonics lead to the potential for magma progression through the crust. Hence, loading during inversion tectonics dramatically change the maximum principal stress orientation ($\sigma 1$) and affects magma propagation more than the individual extension or compression regimes. Local stresses are dominated by a deep reservoir at 15-18 km depth. It is this reservoir that largely controls the dyke paths to the surface and the location of their eventual eruptions.